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ABSTRACT

A discussion is provided of how breakthroughs in the application of computers in the manufacturing of automobiles affect the development of community college programs, with particular emphasis on how Michigan community colleges have developed a capacity to respond to changes in this field. First, the paper explains what computer-based manufacturing technologies are and looks at the forms and levels of their implementation. Next, the effect of computer-based technologies on jobs and skills is analyzed, concluding that the deployment of the new manufacturing technologies will eliminate certain jobs, but also raise the skill levels of the remaining workers in manufacturing. The community college response to new technology is examined next, including a critical analysis of errors made by community colleges in the design and development of robotics programs. Next, Michigan's experiences with respect to the development of computer-based manufacturing are described, highlighting the creation of the Industrial Technology Institute (ITI) to develop and utilize advanced manufacturing technologies. After reviewing the growing relationship between the ITI and the state's community colleges, the paper looks at lessons that have been learned during the past 2 years of joint ITI-community college activities and explores three areas in vocational-technical education that offer particular challenges and opportunities for community colleges. Finally, concluding comments caution that training is not a substitute for an employment policy and that the issue of whether public education can meet the training challenges of the new manufacturing technologies is still open. (EJV)

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May, 1987

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Introduction

While much of the popular or futuristic literature concentrates upon the "dramatic" breakthroughs in the applications of computers in manufacturing, community colleges are faced with the very practical question of determining how these trends actually translate into programs for students and local business and industry. The purpose of this paper is to discuss how the new manufacturing technologies affect the development of community college programs, and in particular, it will concentrate on how Michigan community colleges have developed a capacity to respond to changes in this critical area.

What Are Computer-Based Manufacturing Technologies?

The scope of manufacturing industries has been dramatically altered by the application of the computer (See Chart No 1) .[1] Actually, many of the specific "new technologies," such as Computer Numerical Control and Computer-Aided Design, were developed in U.S. industries in the 1950s and early 1960s, but the widespread implementation of these techniques did not occur until the late 1970s. The initiation of international competition in American manufacturing forced many firms to turn to computer devices as a means of both lowering their production costs and producing more reliable and better quality products in the marketplace. The implementation of these technologies and their subsequent development have always been market-driven.

Computer-controlled manufacturing operations, however, are only the first step in the process (See Chart No. 2). The major economic "pay-off" for computer-controlled devices, of course, is not in the operation of one device, but the ability to integrate a

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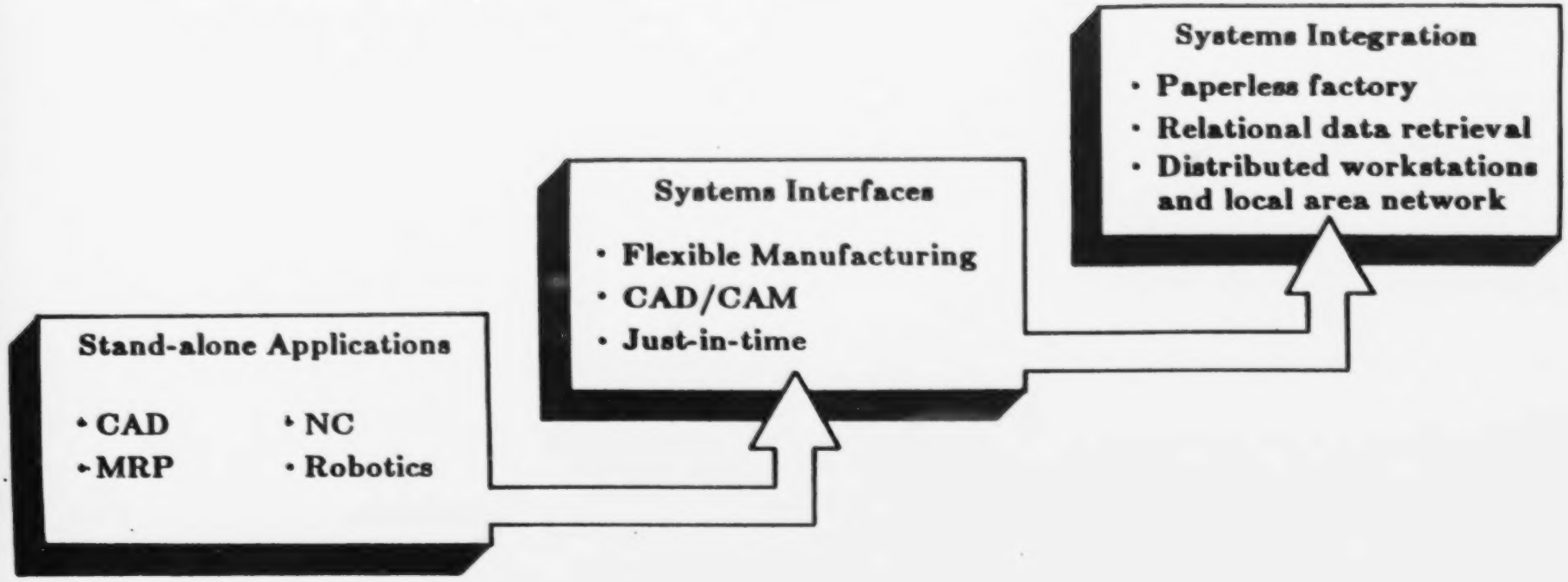
[1]For the purposes of this study we understand computer-based manufacturing technologies to mean the application of computer technology to the planning, design, and manufacturing of automobiles. This includes both the "hard" technologies such as Computer-Aided Design, Computer Numerical Control, and Machine Vision, and the "soft" technologies which use computers to "manage" the process such as Statistical Process Control, Just In Time, and Computer Assisted Process Planning. For an overview of the area, see: editors of the American Machinist, Computers In Manufacturing (New York: McGraw Hill, 1983).

Chart 1

Computer-Based Technologies

- Computer-Aided Process Planning
- Statistical Process Control
- Numerical Control/Computer-Numerical Control Machine Tools
- Programmable Controllers
- Computer-Aided Design
- Computer-Aided Engineering
- Local Area Networks
- Group Technology
- In-Process Automatic Inspection
- Industrial Robots
- Automated Material Handling Systems

Chart 2


Systems Integration
• Paperless factory
• Relational data retrieval
• Distributed workstations and local area network
Systems Interfaces
• Flexible Manufacturing
• CAD/CAM
• Just-in-time
Stand-alone Applications
• CAD
• NC
• MRP
• Robotics

number of different machines into a comprehensive system. Thus, the goal of Computer Integrated Manufacturing (CIM) rapidly superseded the sole application of a computer-controlled device upon one machine. Most observers believe that the real impact of computer-based technologies will arrive when they can be operated by a company in a coordinated fashion.[2]

While the new computer-based technologies are composed of specific on-the-plant-floor machinery, such as CNC, Robotics, Automatic Guided Vehicles, and Programmable Controllers, there are other computer-based applications in the areas of scheduling, inspection, inventory control, and engineering that are very significant to the operation of a modern industrial firm. These "softer" technologies--such as Statistical Process Control (SPC), Computer-Assisted Engineering (CAE), or Local Area Networks (LAN)--are being rapidly deployed by firms to aid in the goal of greater coordination of the processes at the firm level.

Finally, and perhaps most important for the purpose of this analysis, is that the implementation of computer-based manufacturing processes can take a number of different forms. The flexibility of the systems underscore a point which was often missed in earlier periods of technology implementation: that the design of the work process is not a "technical" issue, but one in which the implementation of technology is mediated by a number of social and organizational factors. There is no "one best" way to deploy a CNC machine in a firm. There are a variety of factors that must be considered; to name a few: the strategy of the firm in the production process, the current skill levels of the operators, and the new products that might be made by the machinery. Ultimately, the choice will be based on optimizing what the firm has determined will be its overall strategic plan.

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[2]It should be clear that this is a very difficult procedure to accomplish--and there are very few actual CIM facilities other than prototype or demonstrations. Rather, many companies have partial developments of CIM through the use of Flexible Manufacturing Systems. For a discussion of the differences between how Japanese and American firms use their FMS systems, see: Ramchandran Jaikumar, Post Industrial Manufacturing, Harvard Business Review, November-December, 1986, pp. 69-76.

The Effect of Computer-Based Technologies on Jobs and Skills

For community colleges, perhaps the most important question is: How does this new technology relate to changes in occupational skill requirements? In general, there have been some misleading views which need to be dispelled. One is the belief that these technologies will create endless new possibilities for "high tech work." There is little empirical data to suggest that new computer-based technologies will create more opportunities in the manufacturing industry. Indeed, a careful examination of one specific computer-based device (i.e., robotic applications) suggests that while there are jobs gained in maintenance, programming, and the applications area, robots have replaced operators. There are about 2.5 workers for every application in standard batch and assembly production. As a result, there is little doubt that manufacturing employment (if the present level of domestic manufacturing production continues to decline) will decline in absolute numbers as more computer-based technologies are deployed. For example, automobile assembly plants used to require 4,000 workers for two-shift operations. They now require only 2800 workers to manufacture the same amount of cars--a decline of 30%. An engine plant has less than 350-400 workers indirectly involved in the production line, and most are in the final operations and testing sections.

The percentage of production workers in the industry has gradually shrunk over the past 50 years, but there has been a long-term trend in raising the skill level of employees. Using examples from the auto industry, there has been an increasing percentage of skilled workers versus unskilled workers in overall industry-wide employment. During the 1940s, there were eight production workers for every skilled worker at General Motors. In 1978, there were five unskilled workers for every skilled worker. Five years later in 1983 the ratio was four to one.[3] In some engine plants, the percentage of skilled workers has reached 30% of the plant workforce, when only a decade ago it was 10%. These long-term trends are expected to continue with the increasing deployment of computer-based machinery. One of the few detailed

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[3]Peter Unterweger, Technology and Jobs, United Auto Workers Research Department, May, 1986, p. 6.

examinations of changing skills in the automobile industry was undertaken by the Canadian government. It predicts a drop in unskilled workers in Canadian plants by 1990, from 62% to 51%.[4]

The deployment of computer-based technologies intensifies the long-term trend of rising skill levels within all manufacturing occupational categories. The Manufacturing Studies Board conducted a study of 16 major plants that have extensively introduced computer-based manufacturing technologies. The study indicated a significant increase in skills necessary to conduct most hourly engineering and management work. All plants visited by committee members had increased their training programs for all occupational categories significantly since they adopted computer-based equipment.[5]

Although there is an increase in the necessity of specific technical skills, there is also an increase in the *types* of skills necessary to implement the new computer-based technologies that were different from past machinery.

Instead of learning a single skill on how to run one machine, workers must develop *overall* skills to integrate data, troubleshoot problems, and understand the relationships among increasingly integrated equipment; in brief, it is necessary to understand the overall process of production and their role within it. The new training requirements are skill-oriented, based around principles of design and mechanical or electrical engineering theories. But also included in the requirements is the workers' ability to think about the entire manufacturing process.

New technologies have also brought into the workforce a concern regarding interpersonal and "team" skills. This concern has transformed training programs into more general courses in production strategies and troubleshooting, and has raised

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[4]Canadian Occupational Projection System, Report of the Automotive Industry Human Resources Task Force (Employment and Immigration, Canada, 1986).

[5]For a review of the study see: "People and Automation," American Machinists and Automated Manufacturing, June 1986, pp. 98-111.

an issue for management concerning the workers' ability to read, write, and communicate.

In summary, the deployment of the new manufacturing technologies will eliminate certain jobs, but they will also raise the skill level of the remaining workers in manufacturing. Moreover, in the process of implementing these new technologies, there is an immediate demand for increased skills both in the technical and critical thinking skills. Indeed, successful implementation of new technologies is often based upon the availability of these skills among the entire workforce of the firm.

Community College Response

The community college response to new technology has undergone a substantial transition since these "trends" were isolated in the early 1980s. The first reaction was for colleges to begin "training" for these new technologies. Normally, this meant the development of conventional one- or two-year programs, the ordering of "state of the art" equipment, and the assignment of faculty to the new program area. This was the initiation of high tech programs of less than a decade ago.

Despite the warnings by a few analysts that the high tech jobs were not very substantial, community colleges often pushed ahead with programs in areas which were restricted to the new technologies. An example can be found in the area of robotics. The belief that thousands of robots were rapidly being placed into industrial facilities in the United States made it possible for some analysts to see robotic technicians as a major "new occupation." Needs assessment studies were done--usually citing national trends from a variety of "futurists"--and were merged with a few quotations from the business press. This produced a plethora of robotic technicians programs. It was estimated that in one year Michigan community colleges would be turning out enough robotic technicians to serve local industry for the next decade.[6] These training programs which were rapidly filled to capacity during the industrial recession of 1982,

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[6]See: H. Allan Hunt and Timothy Hunt, Human Resources Implications of Robotics, Kalamazoo, Michigan, 1984.

quickly emptied as the word went out into the student bodies that there were no longer any jobs in this area.

There were at least three errors made by community colleges in their need to design robot programs. First, the colleges tended to look at *national* forecasts usually not made by those close to local industrial and technical trends. Most of these forecasts were inherently optimistic in that they did not take into account either the market conditions affecting each industry, or the specific limitations of the technology itself. Thus, while industrial robots had proven to be very useful in some specific assembly and material handling jobs, they were expensive and very inappropriate for many other types of factory work.[7] In addition, there is a natural bias on the part of manufacturers to overestimate their employment needs in new occupations so as to insure a healthy oversupply of labor from which they can draw their workers. A community college has an interest in this regard which may be different than that of industry; thus, an independent analysis must be undertaken.

The second error of the community colleges was to develop a program to implement the robot instead of understanding the process (i.e., the robot is a combination of hydraulic and mechanical systems which are often controlled by a computer-based programmable controller). The robot is not often isolated from other equipment, but is integrated through a programmable controller. Thus, a robotic technician is a good electrical, mechanical, or design generalist with specific specialties in either the area of robotic controls, mechanical repair, or design. In other words, the focus on the "robot" failed to examine the interrelationship of the entire manufacturing process which is a new area of occupations for community college students.

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[7]There is an interesting difference between the technical implementation of the robots in the United States and in Japan. The Japanese tend to deploy very simple robotic applications, while originally the U.S. robotic industry was an outgrowth of scientific concerns to clone human actions. Thus, in the U.S. the goal was to design a robot that could do what humans do while in Japan the robot was designed to undertake tasks the human could perform.

Finally, and perhaps most importantly, the community colleges tended to build robotic programs for their entry level students when the immediate need in the American industrial sector was in the manufacturing facilities' *present work force.* Thus, the two-year programs locked students inside a curriculum that was simply too far removed from the "real world", and at the same time, firms were in urgent need of having their present workers understand how to program and repair the robots already being deployed on the shop floor.

Indeed, this last error is significant in revealing "new challenges" the computer-based technologies offer to community colleges. Despite their remarkable ability to make production of goods cheaper, more efficient, and more reliable, there is a remarkable slow deployment of computer-based technologies among American manufacturing firms. This is especially true among small- and medium-size firms which form the bulk of the American manufacturing establishments.

The Industrial Technology Institute recently completed an extensive survey of 1,386 manufacturing companies in the Great Lakes Region of the United States. There were major differences between the implementation rates of large and small companies (see Table No. 1). For example, the robotic adoption rate for plants with less than 50 employees is 3%, and for firms over 500 employers it is 30%. For CAD, going from small, to medium and large plants it was 12%, 21%, and 49% respectively. For NC/CNC, 17%, 31%, and 61%. For most technologies, the implementation rate for larger establishments is several times that of smaller plants.[8]

There are many reasons for these low adoption rates, but one often cited as a barrier by smaller firms, is the lack of trained personnel to choose, implement, operate, and maintain the equipment.[9] Thus, the issue of training for new technologies for many of these firms becomes *part of the process of implementation.* For the community

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[8]Industrial Technology Institute, The Survey of Manufacturing Technology Adoption, Center for Social and Economic Issues, 1987.

[9]James Jacobs, "The Training Needs of Michigan Automobile Suppliers," July 1986.

TABLE 1

GREAT LAKES REGION
IMPLEMENTATION STATISTICS

Database: 1386 establishments
Firm Definitions: Small (39%) 10-49 employees
Medium (37%) 50-249 employees
Large (24%) 250+ employees

Percent of establishments which have the following technologies:

	SMALL	MEDIUM	LARGE
Auto Inspec	3	10	30
Robots	3	10	32
Material Handling	3	10	26
CAD	12	21	49
CAE	4	6	29
NC/CNC	17	31	61
Program Controller	11	27	50
Production Planning	50	78	86
Local Area Network	9	16	40
Group Tech	12	23	28
SPC	18	38	60

college, this means the institution could not simply react to the firm's request for training, but must develop ties with the firm in order to help with the process of implementation. In short, the new technologies became another concrete means by which the community colleges could become directly involved in the economic development activities of their communities--particularly in relation to small- and medium-size firms.

In a very real sense, the entrance of firms into the area of training for manufacturing technologies provided a "back door" to issues of economic development. For example, if an auto supplier firm was able to secure training from a local community college in Statistical Process Control (SPC) and, as the result of that, win a sizable new contract from one of the original equipment manufacturers, then the college, firm, and community benefited. The customized training now undertaken at many community colleges implicitly recognizes the legitimate "interest" of the firm as part of the community that needs to be served. Perhaps the greatest long-term effect of the impact of computer-based technologies upon community colleges is in this area: they have aided in forging a new commitment on the part of the community college economic development of their areas through the initiation of customized training programs.

Michigan Experience

The state of Michigan is a major manufacturing area. As the home of the automobile industry--perhaps the largest single domestic consumer of new computer-based manufacturing technologies--state policy makers are concerned with the development and implementation of these technologies. Part of Michigan's economic development approach has been to support the development of computer-based manufacturing equipment firms to develop an "automation alley" in the state. If Michigan industry were to remain competitive, firms would need to "get smart" through the rapid deployment of computer-based manufacturing technology.[10]

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[10]For the development of this perspective, see: "Task Force for a Long-Term Strategy," The Path To Prosperity, Michigan Department of Commerce, November 1984.

One aspect of the state strategy called for the creation of an applied research center in advanced manufacturing technology. In 1982, the state of Michigan, along with the Kellogg and Dow Foundations, funded the Industrial Technology Institute whose primary goal is the development and utilization of advanced manufacturing technologies. The Institute is a not-for-profit research development and deployment organization, composed of over 120 individuals, primarily from engineering backgrounds in manufacturing and computer science. About 45% of the annual budget comes from contract research applications work with industrial clients. ITI is divided into "laboratories" of specialists in various areas of manufacturing. The Institute possesses one of the few FMS systems in the United States entirely devoted to research; a conformance testing center for Manufacturing Automated Protocol (MAP) systems, and with the establishment of the Center for Social and Economic Issues a commitment to examine the "human side" of technology issues.

What makes ITI different from any other R&D organizations is: a) the institutional commitment to support economic development activities; and, b) the belief that the issues of implementation or deployment are often equally significant to the narrow technological questions in determining the successful implementation of the new computer-based equipment.

Even in the original plans of the Institute there was a belief that community colleges could play a role in the process. The original documents called for community college participation and, therefore, Al Lorenzo, President of Macomb Community College was placed on the Board of Directors of the Institute. However, the specific means that this implementation process would be carried out was not clarified until the Institute actually opened in 1984. Moreover, the initiation of the Institute and its original funding sources in the state government originated from the Governor's Office for Economic Development and the Michigan Department of Commerce--there was little direct involvement from the Michigan Department of Education.

Independent from this State action, however, Michigan community colleges had begun to organize their own economic development activities. An economic development network was developed in 1982 to promote a relationship between the 29 colleges and the State efforts of economic development. In addition, in 1984 the Governor's Office on Job Training awarded a $500,000 grant to Jackson Community College to train instructors in the delivery of a Statistical Process Control program designed to be used by auto suppliers to qualify for Original Equipment Manufacturers new quality ratings. What was significant about this program is that colleges were being awarded state funds to develop a program designed to aid one of the identified "critical" industries for retention in the state: automobile supplier firms. This was one of the first recognitions by non-educational authorities of the key role community colleges can play in a coordinated state economic development policy. Second, it was also the first recognition that the community colleges are important "gatekeepers" to small- and medium-size businesses--the foundation firms of the manufacturing economy.

Finally, the development of the program also gave impetus for Michigan community colleges to begin a more systematic approach to the development of ties with local business and industry. Most of the time the programs were run at the firm.

Michigan automobile supplier firms, however, were not only concerned with the implementation of SPC. These firms were faced with real pressures--both from the OEMs and the overseas competition in parts manufacturing to not only obtain greater quality but to reduce costs. This meant they were in the process of considering the new computer-based technologies. Given the small size of these firms, the training and technical assistance these firms would need in the process could not be generated internally. State decision-makers became concerned with the ability of the Michigan community colleges to have the capability to provide training for these firms during the process of implementation. To meet these objectives quickly, it was decided to establish a formal linkage between ITI and the Michigan community colleges.

Community College Relationship With ITI

In January 1985, an individual faculty member from one of the community colleges was funded by the state of Michigan to conduct a study into the training needs of Michigan automobile suppliers to determine their training needs. An advisory board was established of state business, labor, and community college individuals to guide the study which included:

- visits to 25 automotive supplier firms to identify their training needs for the successful implementation of advanced manufacturing technology;
- a survey of over 200 Michigan automotive supplier firms to identify their present and future training needs;
- on-site interviews with vocational technical administrators from six community colleges in the state; and,
- interviews with eight personnel managers concerning the career ladders open to community college students in the area of computer-based manufacturing technologies.

This lead to a series of reports that have been issued concerning the findings and their implications for public policy.[11]

These findings motivated the Michigan State Board for Public, Community, and Junior Colleges to fund a Community College Office at the Industrial Technology Institute. The purpose of the office was to serve as a means by tapping both the research capabilities and the technological expertise of the Institute for use by Michigan community colleges. This has included:

- conducting a student analysis of a course taught by Michigan community colleges concerning Statistical Process Control;
- developing a feasibility study for determining whether a community college should undertake the development of a high tech center;
- working as an implementation "team" with a company and a community

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[11]For a summary of the funding, see: James Jacobs, Final Report: Training and Public Policy, March 1987.

college where ITI contributes its technical expertise to help the company develop its manufacturing specifications and then integrating the training conducted by the community college;

- developing a Customized Training Institute that will teach Michigan community college staff to better respond to the needs of business and industry;

- conducting a study to determine the career paths for vocational-technical students in advanced manufacturing technologies;

- developing a set of assessment instruments and training modules for computer-based technologies to be used by community colleges;

- providing community colleges with a technical reference and information service which they can make available to small- and medium-size firms in their area.

The office is staffed by a faculty member from Macomb Community College. In the future, it is anticipated that some form of internship will develop between other Michigan community college staff and ITI.

The relationship between ITI and the Michigan community colleges, however, is not simply one-way. In turn, the community colleges are considered vital to the economic development interest of ITI. Manufacturing in the United States in general, and specifically Michigan, is heavily concentrated in smaller units. About 80% of Michigan manufacturing firms have less than 100 employers and they provide a significant proportion of higher paying jobs to most of the urban areas in the state. Moreover, as the original equipment manufacturers continue their "hollowing out" processes and become more assemblers of automobiles than part makers, a critical question is whether these smaller manufacturers can capture this new business.

One strategy to insure the long-term success of these firms is through the implementation of computer-based technologies. In this process of technical assistance to small firms, the Michigan community colleges are considered the "gatekeepers." to these businesses. Indeed, an innovative state program, the Technology Deployment

Service, which was developed in close consultation with ITI, is based on the use of the community colleges as "industrial" extension centers similar in function to the 19th century agricultural extension policies of many midwestern states. Their strategic location, plus the flexibility and the willingness to serve the interest of the local community, make them a needed complement to the mission of the Industrial Technology Institute. Thus, part of the Liaison Office function is have ITI utilize the community college system for the successful deployment of new manufacturing technologies.

What Has Been Learned

In the past two years of joint ITI-community college activities, a number of lessons have been learned that may be applicable to other community colleges.[12]

1. A good program in computer-based manufacturing technologies starts by adapting to the specific needs of its major clients. In large part because the implementation of this equipment is so driven by the marketplace, the specific design of the training must be generated from the needs of the clients. Thus, community colleges must seek to have very accurate information concerning not just the technologies *but the way they are being implemented* by the local industry. For example, in the technology of Computer-Aided Design, the computer terminals can be used to quickly generate sophisticated and accurate designs of parts, compared to some industries that still use blue prints. In that sense, the computer-aided design equipment serves as an automated drafting system which means programs in CAD should strive to support advanced CAD techniques in finite element analysis, solid modeling, and kinematics.

   On the other hand, if the industries in the area are using CAD as a means to make a transition to the manufacturing of parts (i.e., to be able to have the ability to send messages to the machining centers to create that part), then CAD-CAM means that operators must have an intimate knowledge of machining theory and practice. The design of the curriculum is a different sequence because the needs of the operators are different.

   This attention to the patterns in the local industry is not found among many community college vocational programs who often take a few remarks from

[12]Many of the following suggestions are confirmed by a recent empirical study of "high technology" programs conducted by the National Center For Research In Vocational Education. See: William L. Ashley, Ernest L. Fields, and Judith M. Boylson, Quality Indicators For High Technology Programs, March 1987.

an advising board member as sufficient grounds to determine the growth of the program. Indeed, too many community college staff prepare expensive equipment purchase lists, often without examining the local industrial trends for the use of this equipment.

2. Following from the first statement, a good program must also understand the different needs of the clients (i.e., the students who are enrolled in the programs). In technical programs, three types of students are normally found: young students entering the job market for the first time, workers coming back to school for additional training, and older workers displaced from their previous employment (or in transition back to the workplace). Each requires a different community response to training for the new technologies.

   For the young people entering the workingforce, the programs should contain broad generalized courses that teach fundamentals and give a basic understanding of design, mechanical, or electrical technology. These will provide employers with young workers who are grounded in basic technical skills. These programs should be constructed with the assumption that these students will be given more specific training by firms on particular equipment or processes found at firms that will hire them. There is strong support among manufacturers for entry level workers to possess good technical basic skills which serve as a foundation for further training. If possible, a cooperative education program should be developed to expose students to the workplace and the direct experience with computer-based equipment.

   For workers on the job, they might receive specialized customized training in particular processes, or particular new equipment. This training is often best done at the plant of the firm, and often in conjunction with the vendor training. In general, these students need programs which are particularly geared to the individual needs of their employers. In addition, they may need assessment and specific programs that will permit them to advance in their careers. In the preparation of these programs, community colleges should not overlook the possibility of designed programs for executives and engineers from these firms.

   For the third group, many of whom have some specific vocational and technical experience, there needs to be training in basic skills of reading, writing, etc., as well as technical skills often in very specific areas in order to reassume employability. These programs should be short and based around an understanding as best as possible on the individual "career" paths open in the local industry for individuals entering that field. Given the special backgrounds of these individuals, training needs to be accompanied by a

substantial commitment to placement and job search skills which again are often not found in vocational technical departments at community colleges.

Successful training in computer-based technologies calls for community colleges to segment their market. This means more attention to the design of training, the continual assessment and adjustment of programs, the need for continual staff development in specific technical fields, and greater sophistication at identifying new skill requirements. It also means less attention to getting "state of the art" equipment (which remains in that state for usually less than six months!) and brand new centers. In a sense, the community colleges need to absorb the lesson that industry has learned about the new manufacturing technologies: it is the means by which humans interact with the new technology that provides the cutting edge, not the technology itself.

3. Computer-based manufacturing technologies need a greater skilled workforce which often forces community colleges to respond simultaneously in three separate skill areas.

The first is in the area of basic skills training. All levels of the workforce in manufacturing are faced with unprecedented demands to read, write, and think intelligently on their jobs. Indeed, many companies now assume that the occupational half-life (the length of time when half of the knowledge and skills needed by workers to perform their jobs are obsolete) has declined from 7-14 years to 3-5 years. Almost all workers in manufacturing are faced with the issue of retraining which means the ability to "know how to learn." Too often, community college vocational programs were based on learning from repetition as opposed to the developing critical thinking skills. Learning to "know how to learn" is especially important for the new student population where education must mean the ability to explore the theoretical issues involved with the technology. This will provide a better basis for further specialized training.

A second concern centers around the need for integrative skills or multi-skilling. This is somewhat a controversial issue for while it is clear that workers need to have more than one skill, there is less empirical proof that "simplified" job classifications really increase skill levels.[13] The computer-based technologies are calling for the development of work teams, and other collective work situations that require a different approach to the training of an individual worker in a skill. The ability to work with others, to be able to make group decisions, and to take collective responsibility become

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[13]For a discussion of the debate, see: " Progressive Work Pacts Split UAW," Automotive News, April 6, 1987, p.1

important new areas of concern that need to be reflected in the training programs.[14]

Third, the new computer-based technology requires skills which are much more of an intellectual character than those of preceding non-computerized technologies.[15] This means the need to shift the perception of factory jobs as some "dead end" mindless work that would not be attractive to many community college students. On the contrary, the mental skills necessary for work in a computer-based manufacturing environment are very demanding. It is necessary for community colleges to begin recruitment of a new group of students into their vocational programs.

4. The new technologies also challenge the present community colleges' ability to broaden their definition of appropriate manufacturing curricula. In the past, the community college served primarily as a training ground for hourly operators and skill trades workers in manufacturing; the new computer-based technologies require training *among all occupational groups*. For smaller firms, this in particular has meant the need for training of executives and first-line supervision. In large part, the implementation of the technology is first contingent upon the ability of executives to become familiar with their specific capabilities of the new equipment. New curricula must be inserted which include management awareness sessions, technology briefing, and the initiation of courses in the cost-justification of the new equipment. For first-line supervisors there is a need to learn about how to manage new technologies. Finally, the demands for knowledge of computer programming and language-skills often found in the business departments need to be combined within the vocational technical areas to provide a fundamental background for computer-based manufacturing technologies.

These changes also insert a number of other disciplines and approaches directly within the vocational technical area. They provide a stimulating combination of liberal arts and occupational skills, and will challenge the organization of community colleges. But in the process, they will revitalize the vocational education sector and provide meaning for much of the liberal arts curriculum.

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[14]The Japanese automaker Mazda, for example, in its assessment for new workers at its Flat Rock facility is demanding that they be evaluated in terms of their ability to "cooperate" with others on the job.

[15]This has been discussed in some detail by Louis Tornatzky and Rocco DePietro, "Computer-Assisted Manufacturing: Training In What By Whom and For Whom?". Presented at the Work In America Institute, February 26, 1987.

5. The more narrow the specific training needs of a firm on the new technologies, the less likely community colleges should play a role as a sole source. Today, the bulk of equipment-specific training is done by the vendors, and there appears to be no long-term change wanted by firms. Indeed, it is logical for vendors to off that service. They know their equipment best, and they have the most up-to-date models. Given the general cash shortages most institutions face, it would be infeasible to openly compete on all levels with private training vendors. The issue is how to develop some sort of "mesh" with the vendor where perhaps the instructors from community colleges are trained by the vendor and they take this training into a small- and medium-size firm. Vendors are far less able to handle the needs of smaller manufacturing units and there are many opportunities for joint agreements to be undertaken. In addition, community colleges can offer other services to complement these functions, especially in the area of basic skills preparation and technical assessment. It would appear more fruitful to work with the equipment training vendor than to see them as competitors.

New Challenges Ahead

Obviously, these approaches present some new opportunities and challenges for the traditional vocational-technical education concept at a community college. There are many, but three appear to be very important:

1. The preceding suggestions for alteration of computer-based technology programs call for a large, stable staff to develop courses, design programs, meet with firms to customize coursework, and remain current in programs. This calls for a new means of financing these activities, particularly in the funds received from state sources. Typically, the activities are funded only if they are "regular courses" leading to a degree or completion of some certificate. While this funding has been important, if community colleges will be able to serve this additional market, they will need either alternative means of state support for these ventures, and/or the ability to charge different rates to firms for their services.

   In the past, many community college programs were sold to business and industry because they were cheaper than those that existed in the private marketplace. However, recent data on training costs indicate that firms are more than willing to pay for the real costs that are much higher *if the training they receive is adequate.* This suggests that community colleges should begin to recover costs through charging adequate fees for their projects. Even on this basis, the costs of community college programs can still be considerably lower than those in the private vendor communities.[16]

[16] A typical equipment vendor will charge at least $1000 for a 40-hour week of training.

However, the issue of how to fund some of these new programs will demand some refinement of the financial concepts that have been used in the past. Again, some of the possible areas of change is the development of formulas where customized training is specially supported by the state because it develops the human capital of the state to insure the retention of business in the community.

2. Another major issue is the question of staff training, not just among the faculty, but the administrators and the support staff. All good programs will need to give faculty increasing amounts of half-time assignments, specific seminars and conferences, and training.

   The staff implications appear to be equally profound. There is the need to maintain a "reserve army" of technically trained staff ready to undertake customized training for firms. How can a technical trained staff be freed from the daily regular teaching activity yet remain supported by the institution? There is not enough flexibility to be able to meet the needs of employers for training. Some schools meet this dilemma by using their "typical" faculty to fill their normal teaching loads, while getting a number of part-timers from industry. While this is adequate in filling classrooms with people, this does not generate professional development, nor do the skills of the faculty reflect back into the regular classes. In the long-run, these dual programs may not be cost-effective and may be untenable given union-management considerations of the colleges.

   In addition to the need to retain faculty for this work, there is also the issue of maintaining other specialized roles of training for courses, ability to conduct management and operator training simultaneously, and the ability to provide technical assistance to firms. These are all critical roles which, at this point, few if any of the traditional sources of staff development automatically consider as important. The issue becomes: How do community colleges take on this training? How much can the skills of business and industry itself be tapped to develop the necessary skills to build a good program in the advanced manufacturing technologies?

3. Finally, there is the issue of how to serve business and industry. The simple rhetorical reply, "give them what they want" is unacceptable. Many firms don't know what they want. Indeed, they often seek out community colleges because as educators they should have a better idea of what should be done in the area of training. Moreover, suppose what the firms want is different from what the college or the *community the college represents wants*. For example, in the areas of customized training, an important issue re-occurs. If thousands of dollars of state monies are used for training of workers, and the plant closes, what residual training benefits can now be kept in the

community? It seems reasonable for the community colleges to demand if public funds are being used for training, then a "training accord" be reached where private industry recognizes the training that has been undertaken by another company. If the purpose of the governmental support for the training is to develop the state human resource base, then it appears reasonable to insure that each worker be given some transferable skill they can take to another job. Companies will, of course, resist these efforts, but it will ultimately benefit them by keeping costs low. It is not accidental that among all industrial countries, the United States is last in per capita spending for industrial training. One reason for this is the unfortunate lack of any sort of national policy.[17] In the absence of this policy, the community colleges must seek to develop it on a regional or state-wide basis.

Conclusion

The lack of a national training strategy may soon come to an end. The growing concern over the loss of the American manufacturing base has initiated a call for an interest in increased training as one potential remedy. In the most market-oriented areas of the Federal government, there appears to be stirring the notion that government monies should be used to train people. No doubt, this will spill over into the community colleges and be utilized to benefit many of the suggestions outlined above. Two words of caution, however, should be sounded:

Training is not a substitute for an employment policy. The slogan, "Keeping America Working" clearly belongs in community college discourse. But it needs to be equally clear that new jobs must be created and new governmental policies must be made that create these jobs. There is no free market that will automatically create manufacturing work in America. There must be some national policy of job creation, and our interest with the training in manufacturing technologies should contribute to these efforts. In that sense it is proper that community colleges continue to be concerned with the lack of a supply of jobs, as well as the present demands of manufacturers for trained individuals.

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[17]For a discussion of industrial training policies in other countries, see: Office of Technology Assessment, Technology and Structural Unemployment: Reemploying Displaced Adults, Washington, 1986, ch. 5.

The issue of whether public education can meet the training challenges of the new manufacturing technologies is still open. While for many public educators, it is axiomatic that the community colleges serve as the source of industrial training, there is no consensus in industrial circles for that view. Most of the large industrial firms run giant private training programs. UAW-GM claims to be the largest private training program in the world. Private vendors increasingly are involved in the training areas--all offering services and courses which cannot be matched by the community college. The community college must find its competitive edge. It is not automatic that the community colleges will become the centers for technical training. However, if some of the restructuring that is suggested in this paper can be adopted, community colleges and American industry will benefit.

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